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Life-Cycle Analysis

Helping reduce lifelong greenhouse gas emissions where you live

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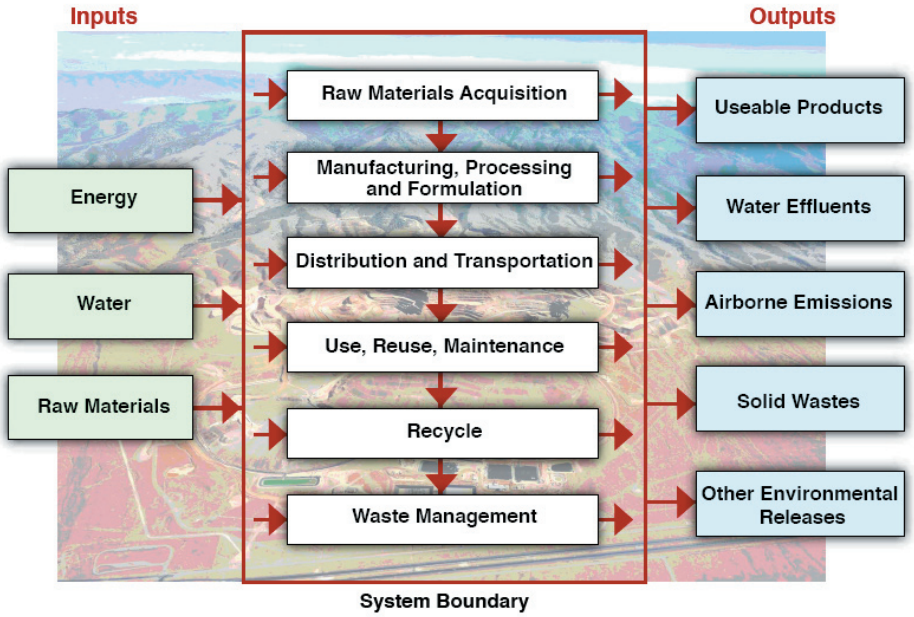
As a climate-aware person with good intentions, you are most likely already taking steps to reduce your personal carbon footprint. You may be purchasing ENERGY STAR®-labeled products when you buy or replace your appliances and electronics. Maybe you've replaced your light bulbs with compact fluorescent lamps or added insulation to your home. You may be driving a hybrid vehicle, or even using public transportation more often.

But what's next? The scientific community, by way of the Nobel Peace Prize-winning Intergovernmental Panel on Climate Change (as well as other researchers worldwide), has urged the world to undertake a radical reduction in its greenhouse gas (GHG) emissions. How can we each reduce our carbon footprints even further?

Eric Masanet of Berkeley Lab's Environmental Energy Technologies Division (EETD) and Arpad Horvath, a professor in the Department of Civil and Environmental Engineering at UC Berkeley, are advancing an analytical method called life-cycle analysis that may help product manufacturers take the next leap.



Life-cycle analysis attempts to quantify the full range of environmental impacts associated with a product by considering all inputs of resources and materials and all outputs of wastes and pollution at each stage of the product's life—including acquiring raw materials (e.g., mining), manufacturing and distributing the product, the consumer's use and maintenance of the product, and its ultimate disposal.

Life-cycle analysis (LCA) is not new, but scientists, manufacturers, and policymakers are using it more and more often to expose opportunities for reducing environmental impacts across the entire life cycle of products, from production to disposal. Masanet and Horvath are working to make LCA more relevant to GHG emission-reduction policies by focusing the method on products that are manufactured or purchased within a specific region. By focusing on regional LCA, they can identify energy-saving and GHG emission-reduction opportunities that may be specific to that region.

The regional approach also helps policy makers focus on local incentives and regulations that may do better at reducing emissions than a one-size-fits-all approach. "The big leap," says Masanet, "is the use of this science by policy makers in the United States, which has not been the case in the past."

In a recent example of such work, Masanet, Horvath, and their colleagues at Carnegie Mellon University have received funding from the California Air Resources Board (CARB) to analyze opportunities for reducing greenhouse-gas emissions during the life cycles of a wide range of retail products commonly consumed in California.

"The goal of the research," says Masanet, "is to develop a reliable LCA approach for the state of California that will allow consumers and policy makers to identify with reasonable confidence those retail products with lower life-cycle carbon footprints. We will also study the total potential for GHG emissions-reduction associated with the adoption of low-carbon retail products in the state."

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To accomplish this, Masanet and his colleagues will develop a life-cycle model that assesses how much energy is used to manufacture the products and transport them to their ultimate users, how much energy they will use throughout their product life, and how much energy will be used to dispose of them.

"A key distinction with our model will be the ability to estimate the in-state versus out-of-state GHG emissions associated with a given product," says Masanet. "This feature will allow us to estimate potential in-state savings associated with low-carbon products, which is important in the context of the state's new AB32 emissions reduction targets."

With this information, they will look for opportunities to improve the energy efficiency of these products at every stage of their life. In effect, they'll provide the information that manufacturers and policymakers can use to minimize the product's GHG emissions, not only by using the most energy-efficient technologies in the product, but also by using the most energy-efficient methods of manufacturing and disposing of them as well. Finally, Masanet and his colleagues will assess the extent to which putting low-carbon-emissions labels on retail products may help the state meet its AB32 GHG emissions reduction targets.

The "greener" PC

Masanet and Horvath have also studied the life cycle of one of the world's most popular consumer products, the personal computer. In a 2006 report, Masanet and Horvath analyzed the GHG emissions of personal computers in California. The state boasts more PCs than any other in the U.S.—the researchers estimate that there were 19 million as of 2005, with the number expected to continue growing. In another study conducted with several Berkeley Lab colleagues, Masanet found that PC manufacturing, use, and disposal in California is responsible for a total of 5.9 million tons of carbon dioxide equivalent per year, equal to the emissions of 1.3 million cars.

At every stage from raw materials to manufacturing and on through disposal and recycling, products like personal computers can have significant environmental impacts.

Based on 2001 figures, the energy required to produce PCs and related components in California was equivalent to 2.7 percent of the energy used by the state's industrial sector, and the energy to operate the enormous stock of residential and commercial PCs in California each year equals roughly 1.7 percent of all the energy used by the state's commercial and residential sectors.

A life-cycle analysis of these PCs suggested seven steps that could reduce their carbon emissions. Among these were increasing the efficiency of the cleanrooms in which PCs are manufactured; maximizing the use of power management software (which automatically puts the PC into sleep mode after a period of inactivity); switching from CRT monitors to LCD flat-panel screens; and maximizing PC recycling in the state. Each step would reduce emissions by hundreds of thousands of tons of CO2 equivalent. In addition to Masanet and Horvath, other Berkeley Lab researchers contributing to this study were Lynn Price, Stephane de la Rue du Can, Rich Brown and Ernst Worrell.

Based on Masanet and Horvath's retail-product carbon-labeling project for CARB, the next step in the process of reducing PC emissions could be to create a low-carbon PC standard and label. While the ENERGY STAR® program labels the most energy-efficient products, comprising about 25 percent of sales, ENERGY STAR® currently defines energy efficiency for PCs based only on their use phase, not during their manufacture and disposal.

Only PCs that meet certain life-cycle requirements could bear a low-carbon label. Production-phase energy use practices might include requiring that manufacturing operations (e.g., cleanrooms and printed wiring board manufacture) and supply-chain practices meet an energy efficiency standard, that PCs have the more efficient flat-panel displays, and that they use a specified amount of recycled material.

Minimizing use-phase energy under the standard would mean that the PC must meet ENERGY STAR® standards for efficiency, have power management software enabled, and meet the Institute of Electrical and Electronics Engineer's IEEE 1621 standard for ease of power management. Finally, a low-carbon PC would have to be disposed of properly. It would be designed to be recycled, with easy disassembly and reduced toxic components, and have guaranteed take-back by the manufacturer, with end-of-life reporting on its fate.

Masanet and Horvath estimate that if every PC sold in California were a low-carbon PC with these features, achievable life-cycle GHG emissions reduction would be more than a million tons of CO2 equivalent per year—equivalent to removing 225,000 cars from California roadways.

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Living the life-cycle way

The funding that Masanet, Horvath, and their colleagues have received from CARB will allow them to apply the same kind of life-cycle analysis to other major products sold in California. The research's final product will be knowledge of the amount of GHG emissions attributable to each product at each stage of its life, and where there are opportunities for reducing those emissions. If the state develops a low-carbon standard and a voluntary labeling program, manufacturers will have the knowledge they need to move noncompliant products toward meeting the standard.

Establishing low-carbon-content standards and labels—and more generally, thinking in terms of the life-cycle emissions of products and how to reduce them—could help the state meet the requirements of Assembly Bill 32 and the Governor's recent executive order. They require the state to reduce GHG emissions to 1990 levels by 2020, with a further reduction to 80 percent of 1990 levels by 2050.

Masanet has also begun a new research project with Berkeley Lab colleagues Klaas Jan Kramer, Lynn Price, and Rich Brown to quantify the greenhouse gas emissions caused by the consumption patterns of California residents.

"A promising way to meet the aggressive GHG reduction requirements specified in AB 32 is to identify and reduce the emissions associated with the personal consumption activities that most influence California's annual energy demand," says Masanet.

This work is funded under an exploratory grant from the California Energy Commission's Public Interest Energy Research (PIER) Program. The new project will provide a detailed model for evaluating the GHG emissions arising from the daily lives of Californian's, including home and transportation energy use and the life-cycle GHG footprint associated with the products and services Californians consume on a daily basis. The researchers will use this model to determine which changes in consumption patterns might offer the greatest reductions in California's total GHG emissions—both inside and outside the state.

Masanet is also developing a regional LCA model for building materials in the United States, funded by the Portland Cement Association. The goal of this work is to provide urban planners and building designers with region-specific data on the environmental impacts of key structural materials, so that they can more accurately estimate the life-cycle environmental tradeoffs of different structural design options based on a building's specific location.

"Such regional specificity can help take LCA from an interesting, theoretical exercise to a real-world environmental analysis tool to drive everyday decision making," Masanet says.

"Engineers need to think differently about how they design products and systems in the 21st century to meet the challenge of sustainable development," says Masanet, who has a joint research appointment with UC Berkeley's College of Engineering. "The EBS Program provides UC Berkeley graduate students with the new skills and perspectives they'll need to become future sustainability leaders in engineering and management."

Additional information

More about Eric Masanet's research is at http://eetd.lbl.gov/staff/masanet/.

Advice from Masanet and Horvath on reducing PC energy use can be found on the Flex Your Power wedsite at http://fypower.org/news/?p=815.

More about UC Berkeley's Engineering and Business for Sustainability Program is at http://sustainable-engineering.berkeley.edu/index.php.